WHAT IS CLAIMED IS:

1       $\cancel{1}$.   A cracking tube comprising:

2   a first layer on an interior surface of the tube; and

3   a second material surrounding the lining,

4   wherein the first layer is an iron aluminide alloy having a coefficient of

5   thermal expansion substantially the same as the coefficient of thermal expansion of

6   the second material over the temperature range of ambient to about 1000 °C.

1   2.   The cracking tube of claim 1, wherein the iron aluminide alloy is

2   a sintered iron aluminide alloy or a composite of iron aluminide alloy.

1   3.   The cracking tube of claim 1, wherein the second material is

2   INCO 803 or HP steels.

1   4.   The cracking tube of claim 1, wherein the iron aluminide alloy

2   includes at least 2 vol. % transition metal oxides selected from alumina, yttria,

3   ceria, zirconia, or lanthanum.

1   5.   The cracking tube of claim 4, wherein the iron aluminide includes

2   at least 14 wt. % aluminum.

1   6.   The cracking tube of claim 4, wherein the iron aluminide alloy

2   includes an additive present in an amount which improves metallurgical bonding

3   between the oxide filler and the iron aluminide alloy, the additive comprising at

4   least one refractory carbide.

1   7.   The cracking tube of claim 1, wherein the iron aluminide alloy

2 comprises:

3   14-32 wt.% Al;

4   10-14 vol. % transition metal oxides;

5   0.003 to 0.020 wt.% B;

6   0.2 to 2.0 wt.% Mo;

7   0.05 to 1.0 wt.% Zr;

8   0.2 to 2.0 wt.%Ti;

9   0.10 to 1.0 wt.% La;

10   0.05 to 0.2 wt.% C;

11   balance Fe; and

12   optionally, ≤ 1 wt.% Cr.

1   8.   The cracking tube of claim 1, wherein the first layer comprises

2 an extruded layer on the inside of the tube.

1   9.   The cracking tube of claim 1, wherein the alloy is in the form of

2 a nanocrystalline intermetallic powder.

3   10.   A method of reforming a hydrocarbon feed in the cracking tube

4 of claim 1, comprising passing of a mixture of steam and the hydrocarbon feed

5 through the cracking tube while heating the tube to at least 800° C.

1   11.   A method of manufacturing the cracking tube of claim 1,

2 comprising the steps of:

3   forming the first layer from a powder of 14-32 wt. % Al, 10-14 vol. %

4 transition metal oxides, 0.003 to 0.020 wt.% B, 0.2 to 2.0 wt.% Mo, 0.05 to 1.0

5 wt.% Zr, 0.2 to 2.0 wt.%Ti, 0.10 to 1.0 wt.% La, 0.05 to 0.2 wt.% C, balance

6   including Fe, and optionally ≤ 1 wt.% Cr, the powder having been prepared by

7   mechanical alloying, gas atomization, or water atomization techniques.

1   12.   The method of claim 11, wherein transition metal oxides are

2   oxides of aluminum, yttria, ceria, zirconia, or lanthanum

1   13.   The method of claim 12, wherein transition metal oxides are

2   Al_2O_3, Y_2O_3, CeO, Zr_2O_3, or LaO.

1   14.   The method of claim 11, wherein the first layer is formed by co-

2   extrusion with the second material of the cracking tube, the co-extrusion carried

3   out at a minimum of 800 °C by using a cold isostatically pressed (CIP) billet or a

4   hot isostatically pressed (HIP) billet.

1   15.   The method of claim 14, wherein the billet formed by cold

2   isostatic pressing is obtained by reaction synthesis or mechanical alloying of iron

3   aluminide with mixed oxides.

1   16.   The method of claim 11, wherein the second material of the

2   cracking tube is an INCO 803 steel, a HP steel, or one of the Fe-, Cr-, or Ni-

3   based alloys with a minimum of 10 wt.% of Cr or Ni.

1   17.   The method of claim 11, wherein the first layer is formed by

2   thermal spraying techniques.

1   18.   The method of claim 17, wherein thermal spraying techniques are

2   plasma spraying or high velocity oxy-fuel spraying.

1   19.   The method of claim 11, wherein the first layer comprises a

2 cladding.

1   20.   The cracking tube of claim 1, further comprising:

2   an intermediate layer disposed between the first layer and the

3 second material,

4   wherein the intermediate layer has a coefficient of thermal expansion

5 between the coefficients of thermal expansion of the first layer and the second

6 material

1   21.   A method of reducing coking and carburization in a cracking tube

2 having a metallurgically modified surface on the inner diameter surface thereof

3 and the cracking tube is used in an environment in which hydrocarbon feedstock is

4 thermally and/or catalytically converted to hydrocarbon products, comprising:

5   heating the cracking tube to a first temperature at which cracking

6 of hydrocarbon feedstock occurs;

7   flowing hydrocarbon through the cracking tube; and

8   producing an effluent containing a desired hydrocarbon product,

9   wherein the metallurgically modified surface is an iron aluminide alloy

10 having a coefficient of thermal expansion substantially the same as the coefficient

11 of thermal expansion of a second material of the cracking tube over the

12 temperature range of ambient to about 1000 °C, and wherein the modified surface

13 is substantially coke and carburization-free after a period of time in which a

14 similar cracking tube without the metallurgically modified surface of iron

15 aluminide alloy exhibits coking and carburization.

1   22.   The method of claim 21, wherein the iron aluminide alloy

2   comprises:

3   14-32 wt.% Al;

4   10-14 vol. % transition metal oxides;

5   0.003 to 0.020 wt.% B;

6   0.2 to 2.0 wt.% Mo;

7   0.05 to 1.0 wt.% Zr;

8   0.2 to 2.0 wt.%Ti;

9   0.10 to 1.0 wt.% La;

10   0.05 to 0.2 wt.% C;

11   balance Fe; and

12   optionally, ≤ 1 wt.% Cr.

1   23.   In a process of producing hydrocarbon products from feedstock

2   utilizing a cracking tube, the improvement comprising passing the feedstock

3   through a cracking tube having a metallurgically modified surface of iron

4   aluminide alloy disposed on the inner surface of the cracking tube such that

5   feedstock is in fluid communication with the metallurgically modified surface.

1   24.   In the process of claim 23, wherein the metallurgically modified

2   surface is an iron aluminide alloy having a coefficient of thermal expansion

3   substantially the same as the coefficient of thermal expansion of a second material

4   of the cracking tube over the temperature range of ambient to about 1000 °C.

1   25.   In the process of claim 23, wherein the iron aluminide alloy

2   comprises:

3   14-32 wt.% Al;

4   10-14 vol. % transition metal oxides;

5   0.003 to 0.020 wt.% B;

6   0.2 to 2.0 wt.% Mo;

7   0.05 to 1.0 wt.% Zr;

8   0.2 to 2.0 wt.%Ti;

9   0.10 to 1.0 wt.% La;

10   0.05 to 0.2 wt.% C;

11   balance Fe; and

12   optionally, ≤ 1 wt.% Cr.

1   26.   In the process of claim 23, wherein the period of time between

2   successive decoking operations is extended by at least 10 percent as compared to

3   the time between successive decoking operations in a substantially similar cracking

4   tube that does not have a metallurgically modified surface of iron aluminide alloy

5   disposed on the inner surface and in fluid communication with the feedstock.

1   27.   In a cracking tube, the improvement comprising:

2   a metallurgically modified surface of iron aluminide alloy

3   disposed on the inner surface of the cracking tube,

4   wherein the feedstock is in fluid communication with the metallurgically

5   modified surface and wherein the coefficient of thermal expansion of the iron

6   aluminide alloy is substantially the same as the coefficient of thermal expansion of

7   a second material of the cracking tube over the temperature range of ambient to

8   about 1000 °C, the second material an outer material for the cracking tube.

1   28.   In the cracking tube of claim 27, the improvement further

2   comprising:

3   an intermediate layer disposed between the iron aluminide alloy

4   and the second material, the intermediate layer having a coefficient of thermal

5   expansion between that of the iron aluminide alloy and the second material.

1   29.   In the cracking tube of claim 27, wherein the iron aluminide alloy

2   comprises:

3   14-32 wt.% Al;

4   10-14 vol. % transition metal oxides;

5   0.003 to 0.020 wt.% B;

6   0.2 to 2.0 wt.% Mo;

7   0.05 to 1.0 wt.% Zr;

8   0.2 to 2.0 wt.%Ti;

9   0.10 to 1.0 wt.% La;

10   0.05 to 0.2 wt.% C;

11   balance Fe; and

12   optionally, $\leq$ 1 wt.% Cr.